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ON THE EXOSPHERIC TEMPERATURE OF VENUS*

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The exospheric temperature of Venus has been calculated for several different composition models of the atmosphere. The main purpose of these calculations is to determine whether sufficiently different temperatures would be obtained for the various models, so that the results might provide an estimate of the composition of the lower atmosphere once the exospheric temperature is measured.

Atmospheric Models

The only gas so far positively identified to exist in the atmosphere of Venus is carbon dioxide (Kuiper, 1952). Its exact abundance, however, is very uncertain. Estimates have ranged from ^{up to} 80% (Kuiper, 1952, Belton and Hunten, 1967) down to only 1% of the total atmosphere, (Chamberlain, 1965). Also uncertain is the nature of the "other" gas or gases which make up the rest of the atmosphere. Because of its large abundance in the earth's atmosphere, nitrogen is usually quoted as the best candidate, but recently it has been pointed out that if the present atmosphere of a planet is a remnant of primordial gaseous envelope that it acquired during its formation then Ne should also be present in substantial



proportions (Rasool et al, 1966). Table I shows one such composition model which has been derived from the relative abundances of elements in the solar system, as given by Cameron. (1965), and on the assumption that all hydrogen and helium have since escaped.

TABLE I

Composition (% by Volume) of a Model Primitive Planetary Atmosphere after the Loss of Hydrogen and Helium	
CO ₂	60
Ne	25
N ₂	15
SO ₂	Trace
A	Trace

With these considerations in mind, calculations of the exospheric temperature were carried out for atmospheric models in which the CO₂ amount varied from 60% to 1% of the total atmosphere, while the other gas was either N₂, Ne or He.

In all cases it was assumed that the mesopause temperature is 200°K (Rasool, 1963). The temperature profile was computed assuming that the thermosphere is in conductive equilibrium, solar UV is the main source of energy input and the radiational cooling by CO (at 4.66μ) and by O (at 62μ) is the principle mechanism of energy loss from the thermosphere into space. (Details of such calculations are available in, for example, (McElroy et al, 1966, Rasool et al, 1966)).

Results

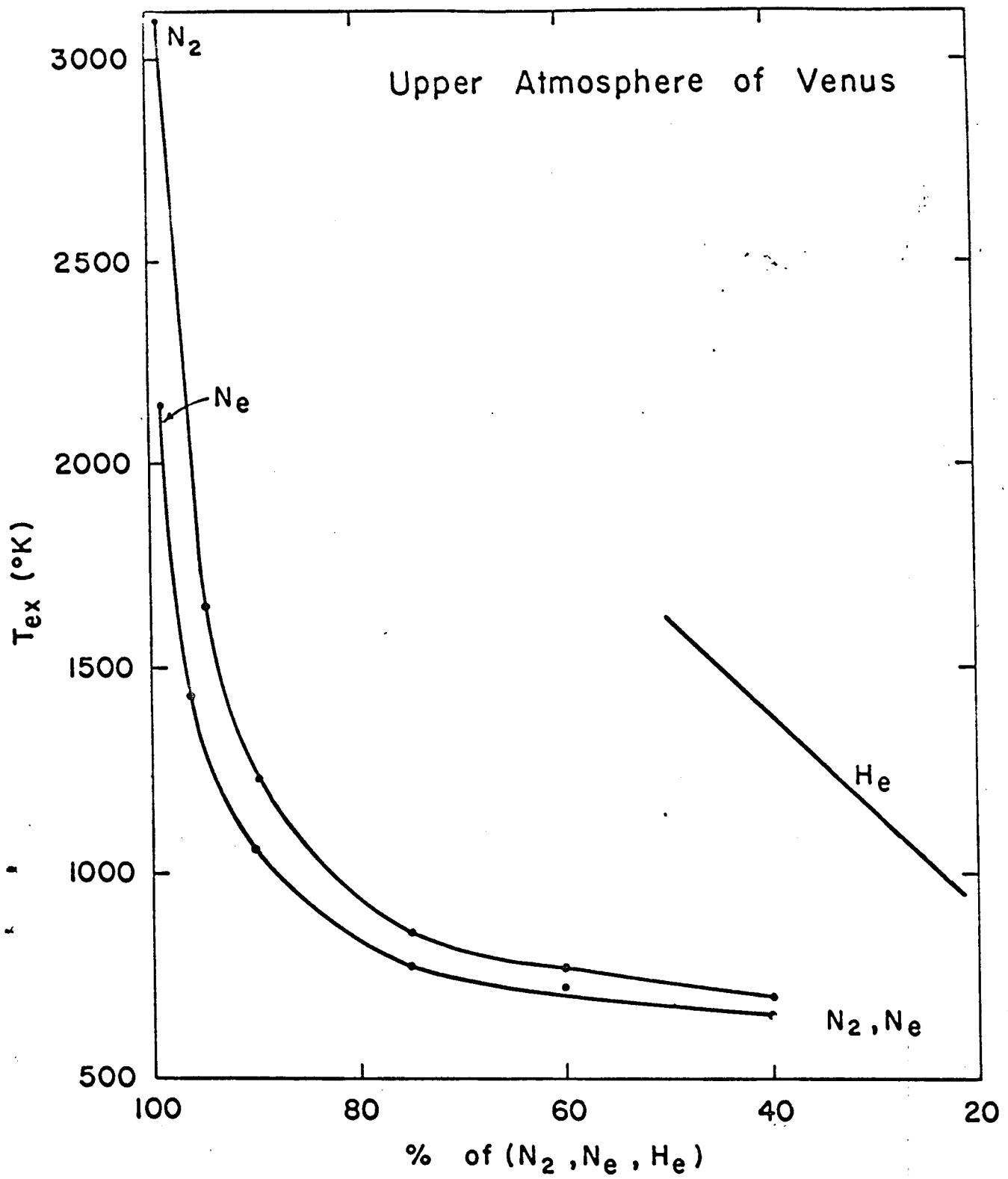
The results are shown in Figure 1. It is interesting to note that the exospheric temperature for atmospheric models containing large quantities of CO_2 mixed with Ne or N_2 is in the neighborhood of $600\text{--}800^{\circ}\text{K}$. However, when the CO_2 abundance is less than 15% the exospheric temperature rises steeply. For 1% CO_2 and 99% N_2 it could be as high as 3000°K . In the case of a He - CO_2 atmosphere, if the helium amount is $> 20\%$, the exospheric temperature is $> 1000^{\circ}\text{K}$. At these temperatures the escape of helium becomes very efficient, and therefore, the models with He $> 20\%$ are highly unstable. For the composition given in Table I the exospheric temperature of Venus will be $\sim 700^{\circ}\text{K}$.

From these studies it appears that a measurement of the exospheric temperature of Venus can help resolve the highly controversial problem of whether CO_2 is a major constituent (Belton and Hunten, 1967) or makes up only 1-10% of the atmosphere (Spinrad, 1962, Chamberlain, 1965).

Independent measurements of the molecular weight of the atmosphere must, however, be made in order to determine if the "other" major gas on Venus is Ne or N_2 . Such observations will throw light on the problem of origin of Venus atmosphere.

FIGURE CAPTION

Figure 1. Exospheric temperatures of Venus for different atmospheric models in which various proportions of CO_2 are mixed with either N_2 , Ne or He. The values of the solar u.v. flux between 1\AA and 1130\AA used in these calculations were taken from Hinteregger et al, 1965. It was assumed that the heating efficiency was 0.5.



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